New records of centric diatoms from Yakutia (Bolshoe Toko Lake): SEM morphology, ecology and distribution

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Abstract. As a result of a SEM study of phytoplankton, the first data on centric diatom species composition in Bolshoye Toko Lake, Yakutia, were obtained. Ten species (*Aulacoseira* — 5, *Cyclotella* — 1, *Discostella* — 1, *Handmannia* — 1, *Pliocaenicus* — 1) were found, and one taxon from the genus *Pliocaenicus* was identified to the genus level. Of these, nine taxa are reported for the first time in the water bodies of the Aldan River basin and *Discostella guslyakovyi* in Yakutia.

Keywords: centric diatoms, scanning electron microscopy, Bolshoye Toko Lake, Yakutia.

Новые находки центрических диатомовых водорослей из Якутии (озеро Большое Токо): морфология, экология и распространение

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Резюме. При изучении фитопланктона оз. Большое Токо с помощью сканирующей электронной микроскопии получены первые данные по видовому составу центрических диатомовых водорослей. Обнаружено 10 видов (*Aulacoseira* — 5, *Cyclotella* — 1, *Discostella* — 1, *Handmannia* — 1, *Pliocaenicus* — 1) и один таксон из рода *Pliocaenicus*, определенный до рода. Из них 9 таксонов впервые найдены в водоемах бассейна р. Алдан, а *Discostella guslyakovyi* — в Якутии.

Ключевые слова: центрические диатомовые водоросли, сканирующая электронная микроскопия, озеро Большое Токо, Якутия.

Bolshoe Toko Lake belongs to the Aldan River Basin and is the largest lake within the Stanovoi Range area (Pshennikova *et al*., 2012). Algae in this waterbody have been poorly studied. There is only one publication about algae (including diatoms) in the lake, based on the samples collected in 2006 (Pshennikova *et al*., 2012), and it lacks data on the species composition. It is mentioned that 64 diatom were found, *Melosira* C. Agardh and *Cyclotella* (Kütz.) Brèb. species had maximum abundance and biomass in both Bolshoe and Maloe Toko lakes; rare species for Yakutia and Siberia, *Cyclostephanos dubius* (Fricke) Round and *Ortoseira roeseana* (Rabenhorst) O'Meara, were identified (Pshennikova *et al*., 2012). An earlier publication gives only four species of centric diatoms in the Aldan basin: *Aulacoseira distans* (Ehrenberg) Simonsen, *A. italica* (Ehrenberg) Simonsen, *Cyclotella comta* (Ehrenberg) Kütz-

ing and *Melosira varians* Agardh (Zakharova *et al*., 2005). Another study on a nameless lake in the basin of the Vostochnaya Khandyga River (a tributary of the Aldan) mentions only *Aulacoseita alpigena* (Grunow) Krammer out of centric diatoms (Potapova *et al*., 2014).

The aim of this study, based on electron microscopy analysis of new materials, was to revise the species composition of centric diatoms in Bolshoe Toko Lake and reveal taxa new for Yakutia.

Material and methods

Bolshoe Toko Lake is of tectonic origin. In the south, it is surrounded by slopes of the Stanovoi Range up to 1500 m high, in the east and west — by gentle ridges up to 1000–1100 m. (Fig. 1). The northern part of the lake depression is a moraine. The lake is 903.8 m above sea level, it is 15.4 км long and 7.5 км wide, the length of its coastline is 51 km (Konstantinov, Efimov, 1973). The water surface area of the lake is 82.6 km^2, water volume — 2.51 km^3. The southwestern part of the lake is the deepest, with a maximum depth of 71 m. It is a running-water lake: the Utruk River rises in the Stanovoi Range at an elevation of 1880 m and flows into the lake in the south, and the Mulam River has its source at the northeastern end of the lake. The duration of ice-free period is 146 days. According to our Secchi disk measurements, water transparency was 5.5 m, and water temperature at sampling sites ranged from 15.2 to 18.4°C. The climate is sharply continental.

Samples were taken between July 7 and 21, 2015 (Fig. 1) from the surface 30-cm water layer using Epstein plankton net (SEFAR NITEX filter fabric, mesh size 15 μm). Material was fixed by not neutralized formalin, the final concentration was 4‰. Diatom frustules were cleaned from the organic matter using the cleaning method of cold oxidation (burning) in with sulphuric acid and potassium dichromate (Balonov, 1975). Cleaned specimens were dried onto stubs, coated with gold using a EIKO-IB-3 sputter coater and examined using a JSM-25S scanning electron microscope operating at 15 kV.

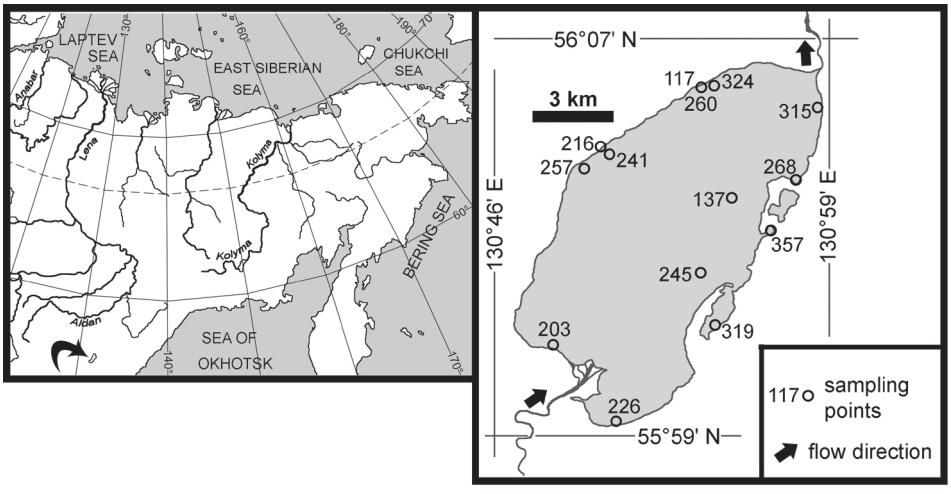

Fig. 1. Location of the Bolshoe Toko Lake and the map of sampling points.

Results and Discussion

Ten centric diatom species have been found. Among them, nine species, except for *Aulacoseira italica,* are reported for the first time in the waterbodies of the Aldan River basin and two in Yakutia (*) and one form was identified only to the genus. Their short descriptions and original illustrations are given below.

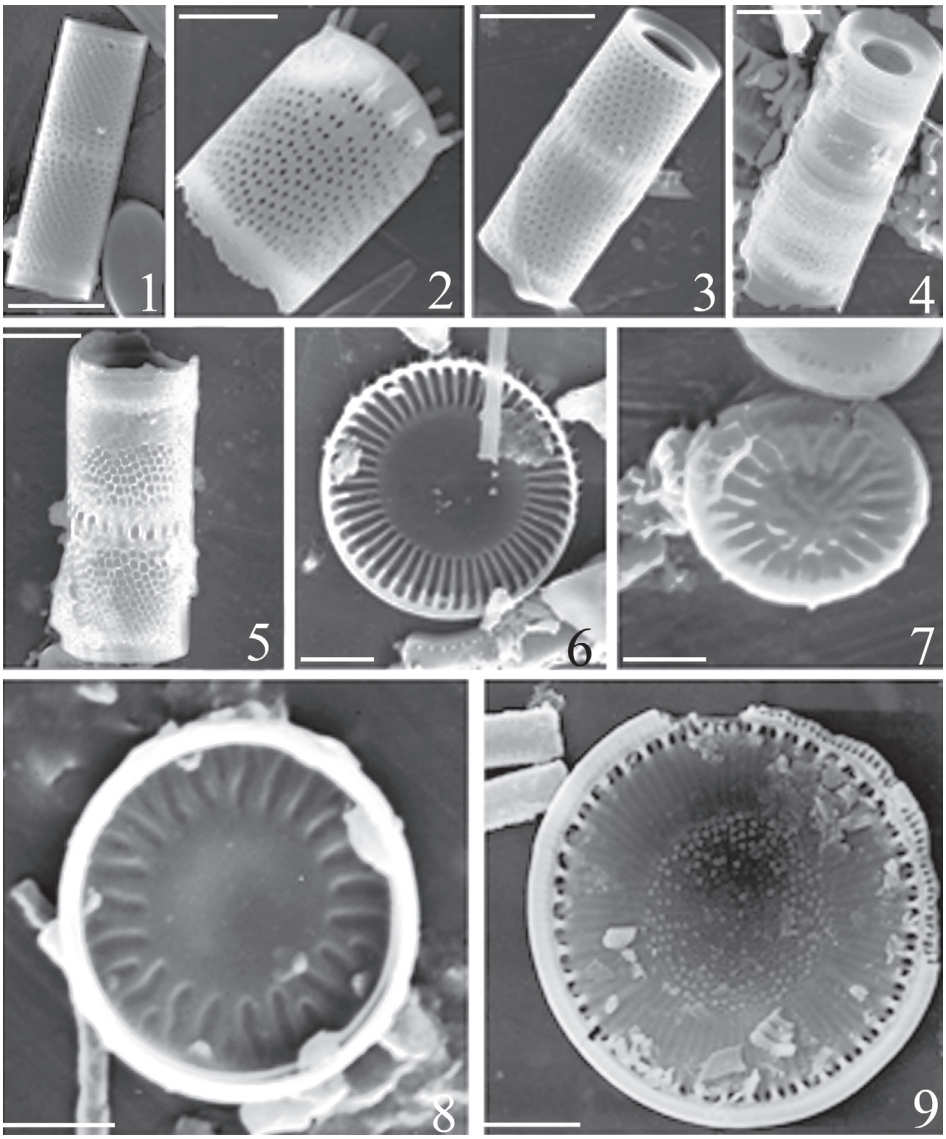

Plate I. *Aulacoseira ambigua* (*1*), *A. italica* (*2*), *A. subarctica* (*3*), *A. lirata* (*4*), *A. valida* (*5*), *Cyclotella meneghiniana* (*6*), *Discostella guslyakovyi* (*7*, *8*), *Handmannia bodanica* (*9*).
1–5, 7 — external valve view; *6, 8, 9* — internal valve view. SEM. Scale bars: *1, 3, 5, 6, 9* — 10 μm; *2* — 5 μm; *4* — 20 μm; *7, 8* — 2 μm.

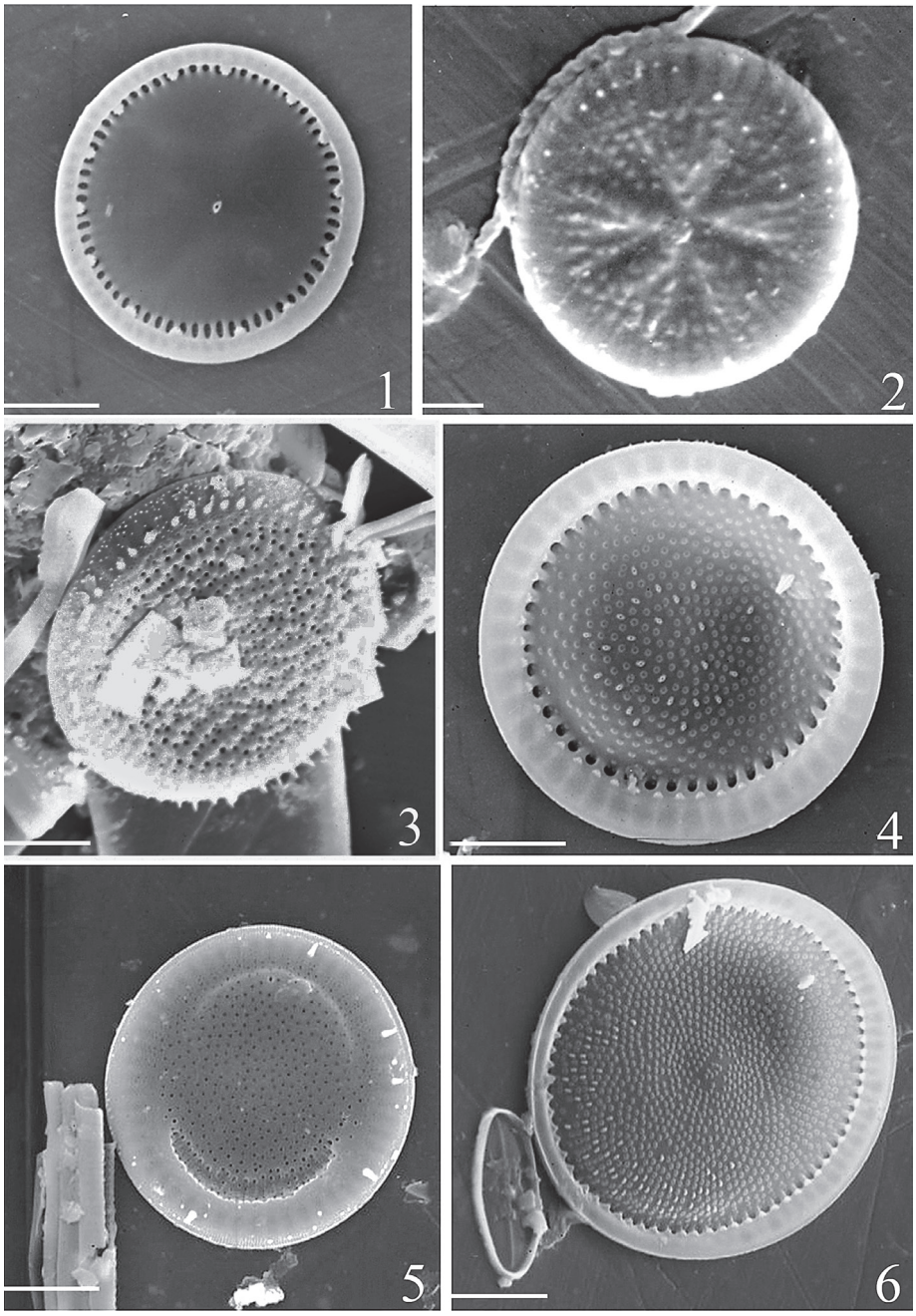

Plate II. *Pantocsekiella rossii* (*1*, *2*), *Pliocaenicus costatus* (*3*, *4*), *Pliocaenicus* sp. (*5, 6*).
1, 4, 6 — internal valve view; *2, 3, 5* — external valve view. SEM.
Scale bars: *1* — 5 µm; *2* — 2 µm; *3–6* — 10 µm.

Aulacoseira ambigua (Grunow) Simonsen (Plate I, *1*)
Valve diameter 7.3–8.6 μm, height 10.4–12.8 μm, rows of areolae 12–14 in 10 μm, areolae 15–16 in 10 μm of a row.

Aulacoseira italica (Ehrenb.) Simonsen (Plate I, *2*)
Valve diameter 11.4 μm, height 13.6 μm, rows of areolae 18 in 10 μm, areolae 10 in 10 μm of a row.

Aulacoseira lirata (Ehrenb.) R. Ross (Plate I, *4*)
Valve diameter 25.6 μm, height 12.7 μm, rows of areolae 8 in 10 μm.

Aulacoseira subarctica (O. Müll.) E. Y. Haw. emend. Genkal (Plate I, *3*)
Valve diameter 8.6–9.6 μm, height 10.4–11.4 μm, rows of areolae 13–14 in 10 μm, areolae 14–15 in 10 μm of a row.

Aulacoseira valida (Grunow) Krammer (Plate I, *5*)
Valve diameter 15.7–23.3 μm, height 15.7–20.0 μm, rows of areolae 10–11 in 10 μm, areolae 10 in 10 μm of a row.

Cyclotella meneghiniana Kütz. (Plate I, *6*)
Valve diameter 31.4 μm, striae 5 in 10 μm.

***Discostella guslyakovyi** Genkal, Bondarenko et Popovsk. (Plate I, *7, 8*)
Valve diameter 4.2–6.5 μm, striae 17–25 in 10 μm.

Handmannia bodanica (Eulenst. ex Grunow) Kociolek et Khursevich (Plate I, *9*)
Valve diameter 42.8 μm, striae 8 in 10 μm.

Pantocsekiella rossii (Håk.) K. T. Kiss et Ács (Plate II, *1, 2*)
Valve diameter 9.5–22.2 μm, striae 13–18 in 10 μm.

Pliocaenicus costatus (Loginova, Lupikina et Khursevich) Flower, Ozornina et A. I. Kuzmina (Plate II, *3, 4*)
Valve diameter 23.3–37 μm, striae 6 in 10 μm.

Pliocaenicus sp. (Plate II, *5, 6*)
Valves oval or round, 15.7–66.7 μm long and 13.6–64.4 μm wide, striae 5–8 in 10 μm.

Pshennikova *et al*. (2012) report *Cyclostephanos dubius* from Bolshoe and Maloe Toko lakes and note that it is rare for Yakutia and Siberia. According to our data, this species is more widespread in both West and East Siberia (Popovskaya *et al*., 2002; Popovskaya, Genkal, 2008; Genkal *et al*., 2010, 2013; Genkal, Bondarenko, 2011; Genkal, Yarushina, 2014). We did not find *Cyclostephanos dubius* in Bolshoe Toko Lake but observed *Pliocaenicus costatus* and *Pliocaenicus* sp., which are morphologically similar to *Cyclostephanos* sp., whereas Zakharova *et al*. (2012) mistakenly referred these forms to the latter. *Pliocaenicus costatus* was found in some lakes of Yakutia (Stachura-Suchoples, 2006; Khursevich, Stachura-Suchoples, 2008), as well as in other lakes of West and East Siberia (Popovskaya *et al*., 2002; Bondarenko, 2006; Popovskaya, Genkal, 2008; Genkal *et al*., 2010, 2013; Genkal, Bondarenko, 2011; Genkal, Yarushina, 2017) and adjacent regions of East Siberia (Bonda-

renko *et al*., 2010; Gabyshev, Gabysheva, 2012, 2013a, 2013b). *Discostella guslyakovyi* is a rare species; it has been known from Lake Nichatka, Cis-Baikal (Genkal *et al*., 2007).

Sixty-one centric diatom species, varieties and forms from 10 genera are known from the waterbodies in Yakutia (Zakharova *et al*., 2005); however, these data need revision since many of them were transferred to other genera. For example, a number of *Cyclotella* species have been transferred to *Discostella* Houk et Klee*, Pantocsekiella* K. T. Kiss et Ács and *Handmannia* Perag. (Houk, Klee, 2004; Khursevich, Kociolek, 2012; Ács *et al*., 2016) and some varieties of *Aulacoseira* Thwaites are now recognized as separate species (Krammer, Lange-Bertalot, 1991).

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